

AutoBalance™ System

Automatic Engine Balancing Technology

Key Features at a Glance

- Continuously adjusts fuel flow to each power cylinder to maintain balanced operation
- Minimize emissions and fuel consumption over a wide range of operating loads
- Reduce mechanical wear and maintenance costs
- Reduce personnel costs and risk by eliminating manual engine balancing
- Supports engines with up to 20 power cylinders
- On-Guard® Diagnostic software for monitoring, analysis, reporting and trending
- Supports automated air manifold pressure control for minimum emissions at varying loads
- Reduce or eliminate these conditions:
 - Detonation
 - Load variation induced balance fluctuations
 - Emissions
 - Fuel consumption
 - Combustion instability
 - Cylinder wear
 - Bearing failures
- AutoBalance™ module supports a web browser interface for setup and monitoring
- Integrates with Windrock's On-Guard® family of monitoring & control modules for an integrated engine/compressor monitoring & control system

AutoBalance™ System

Operators of slow-speed, industrial engines have a new option to help reduce emissions, cut fuel consumption, decrease wear and improve overall machine reliability. All of these benefits result from a properly balanced engine - and can now be achieved using a recently introduced system from Windrock. The technology, called the AutoBalance™ system, automatically maintains optimal balance on engines 24/7. Windrock's AutoBalance™ system provides continuous, peak-pressure balancing for large-bore natural gas-fired engines. The system is designed for slow-speed, integral engines such as Cooper-Bessemer, Clark/Dresser, Ingersoll-Rand, Worthington, and other two- or four-stroke engines with individual cylinder fuel adjustment valves. Typical applications for these engines include natural gas gathering, transmission, processing and storage.

Increasingly tighter emissions requirements are forcing operators to balance engines more frequently in an attempt to remain in regulatory compliance. To date, the only option has been auto-balancing using high-pressure fuel injection systems. The Windrock AutoBalance™ system was developed to be a more practical and cost-effective alternative. Compared to high-pressure fuel injection systems, an AutoBalance™ system is economical and easy to install, and unlike manual balancing, it maintains constant engine balance over extended periods without any human intervention.

System Description

- Components of the system include:
- Stepper-motor actuated fuel valves (replacing manual valves)
 - Pressure sensors on each cylinder

- Windrock E-Guard on-line pressure monitor
- AutoBalance™ module to control fuel valve positions

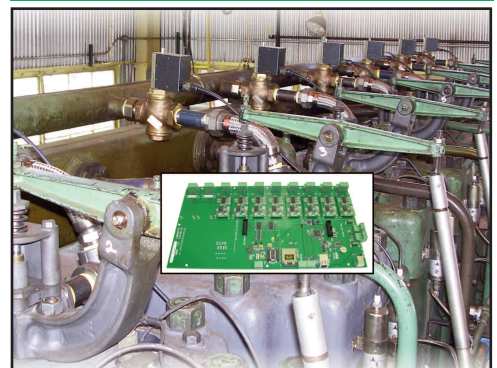
All components are Class 1, Div 2 rated. The AutoBalance™ system is easy and inexpensive to install. The system incorporates self-diagnostics and requires no maintenance other than semi-annual, on-engine sensor calibration during normal unit operation.

Principle of Operation

The AutoBalance™ approach mimics traditional engine balancing, except that it is performed on a continuous basis instead of at routine time intervals. The objective is to adjust fuel flow to each power cylinder in order to maintain peak firing pressures within $\pm 5\%$ of engine average.

The E-Guard module measures peak firing pressure (PFP) statistics and angles for each power cylinder. Proprietary balancing algorithms utilize PFP and combustion statistics feedback to control fuel valve changes. These changes not only balance peak firing pressures but also optimize the consistency of combustion. Peak pressures are continuously maintained at a consistent level across all power cylinders of the engine.

PATENT PENDING



AutoBalance™ system installed on a Clark HBA-8T (turbocharged)

Results

Eliminating unbalanced operation across all operating conditions enables the engine to run with the minimum possible NOx and CO emissions for the engine configuration. Windrock AutoBalance™ systems have demonstrated >25% reduction of NOx emissions (compared to standard controls), with engine balance maintained at $\pm 5\%$ of average despite differing ambient conditions, varying speeds and changing loads.

By maintaining optimum mechanical operating condition, the AutoBalance™ system practically eliminates detonation and uneven load distribution, dramatically improving reliability and reducing mechanical wear. Precisely maintained PFP balance also improves fuel economy from 1% to 5%.

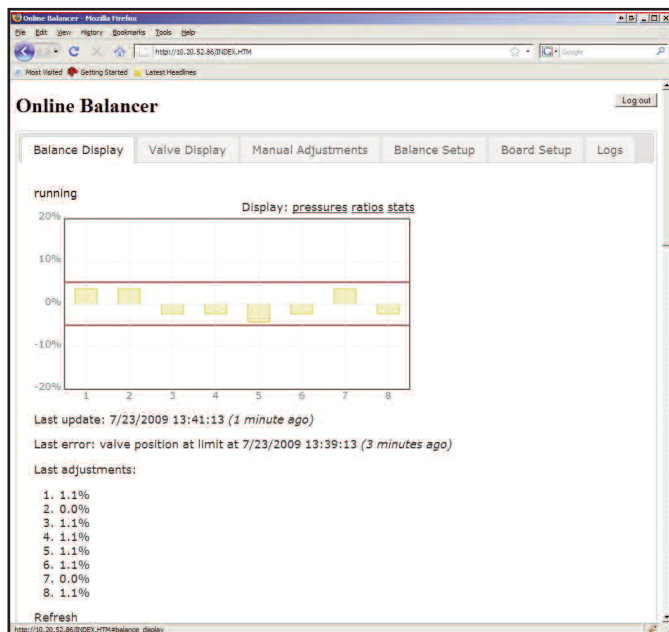
Combining Windrock's AutoBalance™ system with improved air-fuel ratio control and/or pre-combustion chamber retrofits, allows emissions to be reduced to levels approaching high-pressure fuel injection systems but at a significantly lower cost.

As emission regulations tighten and companies look for more environmentally responsible ways to operate, Windrock's AutoBalance system offers a practical solution.

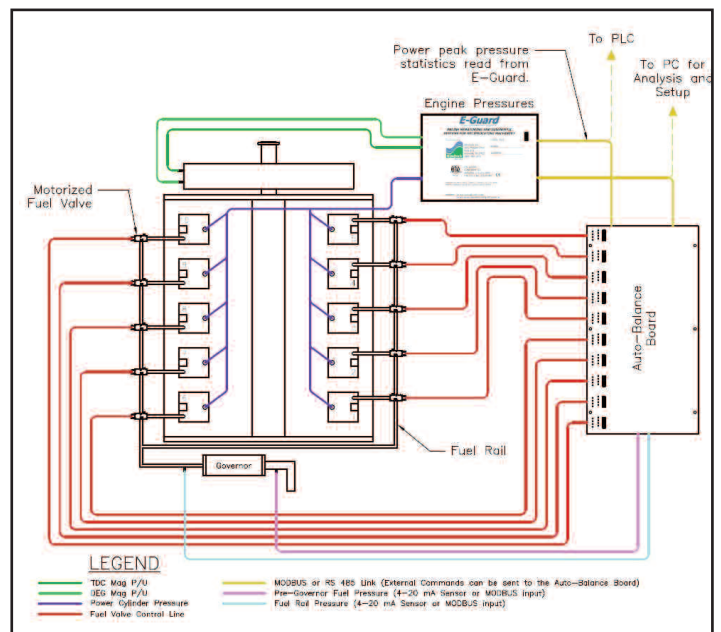
The AutoBalance™ system has a "Fail-Safe" feature that monitors peak pressure statistics, peak pressure angles and compression pressures to diagnose engine or sensor problems and if necessary, disables the autobalance function.

AutoBalance™ Module Specifications

Weight and Size:	Less than 3 pounds 8 inches high x 15 inches wide x 2 inches deep
Number of channels:	Controls up to 10 Fuel Control Valves. Optional slave module available to expand system to 20 Fuel Control Valves.
Hazardous Area Ratings:	Suitable for Class I, Div. II, Group D areas (Certification Pending)
Communications:	Ethernet (10/100) port, 2 x RS-485 Serial
Local Storage:	2 GB SD card (removable)
Power:	20-30 VDC, 1.5 A
Environmental Limits:	-25 °F to +150 °F (operating); -40 °F to +185 °F (storage); up to 95% humidity (non-condensing)



AutoBalance™ display using web interface



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- Pressure sensors on each cylinder
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Windrock, Inc.
1832 Midpark Road, Suite 102
Knoxville, TN (USA) 37921
Phone: (865) 330-1100
FAX: (865) 330-1101
Web Site: www.windrock.com
E-mail: sales@windrock.com